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EVALUATION OF A MIDDLEING CLEANER TAILING FROM THE MOUNT WRIGHT CONCENTRATOR BY IMAGE ANALYSIS STUDIES

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Mineral Processing Laboratory

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Iron Ore Processing

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EVALUATION OF A MIDDLEING CLEANER TAILING FROM THE MOUNT WRIGHT
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by

W. Petruk

ABSTRACT

Ten screened fractions of the middling cleaner tailing from the Mount Wright concentrator were studied to determine the liberation characteristics of the hematite in order to evaluate whether too many free grains are being directed to the regrind circuit. It was found that about 80% of the hematite is in +208 μm (plus 65 mesh) material, with about 50% of this hematite being present as free grains. About 12% of the hematite is in the -104 μm (minus 150 mesh) material and about 90% of it is present as free grains. The unliberated hematite occurs in two size populations, one as grains larger than 100 micrometres (150 mesh), and the other as grains smaller than 100 micrometres. A large proportion of the hematite in the +208 μm (plus 65 mesh) material occurs as the large grains.

ÉVALUATION DU DISTILLAT MOYEN
DU CONCENTRATEUR MOUNT WRIGHT AU MOYEN DE L'ANALYSEUR D'IMAGES

par

W. Petruk

RÉSUMÉ

Dix fractions classées provenant du distillat moyen du concentrateur Mount Wright ont fait l'objet d'une étude portant sur les caractéristiques de libération de l'hématite effectuée dans le but de découvrir si une trop grande quantité de grains libres est de nouveau acheminée dans le circuit de broyage secondaire. Cette étude a permis de constater qu'environ 80 % de l'hématite se trouve dans le matériau +208 μm (passant au tamis de maille plus 65) et que 50 % de l'hématite se retrouve sous forme de grains libres. Environ 12 % de l'hématite se trouve dans le matériau -104 μm (passant au tamis de maille -150) et est présente dans une proportion de 90% sous forme de grains libres. L'hématite non libérée se retrouve dans des populations de deux dimensions dont l'une a une granulométrie supérieure à 100 micromètres (maille 150) et l'autre, une granulométrie inférieure à 100 micromètres. Une grande partie de l'hématite contenue dans le matériau +208 μm (maille +65) se retrouve sous forme de gros grains.

INTRODUCTION

Ten screened fractions of the middling cleaner tailing from the Mount Wright concentrator in Quebec were received from J.M.D. Wilson of the Mineral Processing Laboratory, CANMET on August 3, 1984. Mr. Wilson stated that the cleaner tailing is directed to the regrind circuit of the concentrator even though the mill operators suspect that high percentages of the iron oxides in the product are present as free grains. It is therefore believed that the load to the regrind circuit is too high, and that this causes problems in the concentrator. Mr. Wilson requested that the liberation characteristics of the minerals be determined.

METHOD OF INVESTIGATION

Polished sections were prepared from the fractions and analysed with the image analysis system. The analysis was performed by first obtaining an electron backscatter (BSE) image with the scanning electron microscope (SEM). In this image the minerals having the lowest atomic number (quartz) appear dark grey and those having the highest atomic number (hematite) appear white. Minerals displaying the different grey levels were identified by analysing several grains from each grey level with the energy dispersive X-ray analyser (EDXA).

The SEM-BSE grey level image was collected with the SEM-IPS image analyser, and the image was analysed to (1) determine the wt % of each mineral, (2) the per cent of hematite occurring as free grains, and (3) the characteristics of the unliberated hematite. Fifty fields at a magnification of 40X were analysed for each fraction and the data for the 50 fields were combined into one set.

RESULTS

MINERAL QUANTITIES

The mineral quantities in each fraction were determined by measuring the relative area % that each mineral covers on the surface of the polished section. The results were converted to volume % using the Rosiwal transformation that the relative area % in polished or thin sections is equal to the

relative volume %. Specific gravities (assumed) of the minerals were used to convert volume % to wt %. The results are given in Table 1.

MINERAL LIBERATIONS

The percentages of hematite plus goethite, and of quartz that appear as completely free grains in the polished sections (see Fig. 1, 4, 5, 6, 7 and 8) were determined with the image analyser (Table 2). The results show that in the 1176-832, 832-588, 588-416, 416-294 and 294-208 μm fractions about 50% of the hematite is present as free grains and in 104-74 and -74 μm fractions about 90% is present as free grains.

The liberation data were recalculated to per cent free and per cent unliberated hematite in each screened fraction out of a total of 100% hematite in the calculated head sample (cleaner tailing). The results are reported in Table 3 and plotted in Fig. 9 to show the distribution of free and unliberated hematite in each size range. Figure 9 is plotted on semi-log graph paper so that the area under the top curve is representative of the total quantity of hematite, the area under the bottom curve is representative of the quantity of free hematite, and the area between the curves is representative of the quantity of unliberated hematite. The graph shows that most of the unliberated hematite in the cleaner tailings sample is in grains that are larger than 208 μm (65 mesh).

CHARACTERISTICS OF UNLIBERATED GRAINS

The middling grains were characterized by determining the amount of hematite in each grain and by determining the sizes of the unliberated hematite grains and of the middling grains. To establish a basis for determining the amount of hematite in each middling grain, the middling grains were classified as containing 0-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 80-90 and 90-100% hematite, with the 100% grains being free hematite grains. The number of grains in each class were determined with the image analyser and the results were plotted as histograms (Fig. 10) and reported in Tables 4 and 4a. They show that all classes of grains are present in all fractions that are coarser-grained than 104 μm with the largest number of grains being in the 90 to 100% class (free grains) and in the 0-10% class. The 0-10% class contains hematite grains that are probably too small to be liberated. The sizes of middling grains within the various classes were determined and the number

Table 1 - Mineral quantities in screened fractions

Fraction (μ m)	Wt of material	Wt % of material	Wt %					total
			hematite	goethite	quartz	biotite	amphibole	
+1176	22.3	2.48	82.9	2.1	15.0			100
1176-832	84.2	9.36	77.5	1.3	21.2			100
832-588	112.1	12.46	84.5	7.0	8.5			100
588-416	115.0	12.78	87.9	2.3	9.8			100
416-294	113.1	12.57	55.2	0.05	44.7			100
294-208	136.7	15.19	33.6	0.01	66.4			100
208-147	155.8	17.30	14.3	1.3	82.4	2.0		100
147-104	70.7	7.86	15.3	-	83.0	1.4	0.3	100
104-74	43.9	4.88	47.8	1.9	47.6	2.1		100
-74	46.1	5.12	86.0	1.60	11.7			100
Total	100.0		-	-	-	-	-	100
Head	100.0		53.50	1.76	44.11	0.54	0.03	100

Table 2 - Mineral liberations

Fraction (μm)	Hematite % free	Quartz % free
+1176	0	0
1176-832	40	0
832-588	51	0
588-416	48	0
416-294	57	55
294-208	68	76
208-147	39	71
147-104	40	81
104-74	89	86
-74	94	75
Head	54.4	64.9

Table 3 - Distribution of hematite

μm	Free hem.	Locked hem.	Total hem.	Cum. hem.	Cum. free hem.
+1176		3.85	3.85	3.85	0
1176-832	5.35	8.21	13.56	17.41	5.35
832-588	9.96	9.70	19.66	37.07	15.31
588-416	9.98	11.01	20.99	58.06	25.29
416-294	7.36	5.61	12.97	71.03	32.65
294-208	6.43	3.10	9.53	80.56	39.08
208-147	1.81	2.80	4.61	85.17	40.89
147-104	0.92	1.32	2.24	87.41	41.81
104-74	3.89	0.47	4.36	91.77	45.70
-74	7.74	0.49	8.23	100.00	53.44
Total	53.44	46.56	100.00		

of grains within each size range were doubly classified as a plot of grain class in one dimension, size of middling grain in the other dimension, and number of grains in each classification as the third dimension (Fig. 11).

The size distributions of the unliberated hematite grains in each fraction were determined by measuring the equivalent circular diameter of each unliberated hematite grain (square root of $4/\pi \times \text{area}$). The number of unliberated hematite grains in each size range are plotted as histograms in Fig. 12 and reported in Tables 5 and 5a. The results show that in fractions coarser than 294 μm there are two populations of unliberated hematite, those larger than 100 μm and those smaller than 100 μm . In fractions that are finer-grained than 208 μm most of the unliberated hematite grains are smaller than 100 μm .

The shapes of the free hematite grains in the -74 μm fraction were determined by measuring the circulatory factor where 1 = circle, 0.75 is a square, and minus 0.75 is a pseudorectangle with 0.1 being elongated grains. The data were doubly classified as circulatory vs size and plotted as number of individuals in each class (Fig. 13). The results show that most of the free hematite grains in the -74 μm fractions are pseudorectangular with the largest ones being elongated. This is because hematite tends to fracture as

prismatic grains which are about the size of the hematite crystals. As hematite is broken into grains that are smaller than the crystals the grains will tend to be equigranular.

CONCLUSIONS

The results of this study show:

1. 60% of the hematite is in grains that are larger than 208 μm (65 mesh), with 50% of this hematite being as free grains.
2. 12.6% of the hematite is in grains that are smaller than 104 μm (150 mesh) with 90% of it being as free grains.
3. Only 8% of the hematite is in the 208-147 and 147-104 μm fractions. These fractions contain large amounts of quartz and account for 25.2 wt % of the middling cleaner tailings.
4. The unliberated hematite in the fractions that are coarser-grained than 208 μm is in populations of two sizes, those larger than 104 μm and those smaller than 104 μm .

RECOMMENDATIONS

The following suggestions are made on the basis of the characteristics of the material in the screened fractions:

1. The material should be screened with a 208 μm screen to separate the material that contains great amounts of hematite from the material that contains lesser quantities.
2. The plus 208 μm material should be treated by a process that will recover the free hematite in an iron concentrate, and the tailing from the process should reground.
3. The minus 208 μm material should be treated by a process that will recover the fine-grained free hematite in an iron concentrate, and the tailing from the process discarded as mill tailings.

Table 4. Classes of middling particles

65-100 mesh						
CLASS	FROM	TO	ABS	REL	FREQUENCIES CUM. ABS	CUM. REL
1	0.0000	10.0000	216.	40.00 %	216.	40.00 %
2	10.0000	20.0000	22.	4.07 %	238.	44.07 %
3	20.0000	30.0000	12.	2.22 %	250.	46.30 %
4	30.0000	40.0000	11.	2.04 %	261.	48.33 %
5	40.0000	50.0000	8.	1.48 %	269.	49.81 %
6	50.0000	60.0000	7.	1.30 %	276.	51.11 %
7	60.0000	70.0000	3.	.56 %	279.	51.67 %
8	70.0000	80.0000	8.	1.48 %	287.	53.15 %
9	80.0000	90.0000	4.	.74 %	291.	53.89 %
10	90.0000	100.0000	249.	46.11 %	540.	100.00 %
48-65 mesh						
CLASS	FROM	TO	ABS	REL	FREQUENCIES CUM. ABS	CUM. REL
1	0.0000	10.0000	162.	24.18 %	162.	24.18 %
2	10.0000	20.0000	42.	6.27 %	204.	30.45 %
3	20.0000	30.0000	28.	4.18 %	232.	34.63 %
4	30.0000	40.0000	16.	2.39 %	248.	37.01 %
5	40.0000	50.0000	4.	.60 %	252.	37.61 %
6	50.0000	60.0000	14.	2.09 %	266.	39.70 %
7	60.0000	70.0000	2.	.30 %	268.	40.00 %
8	70.0000	80.0000	5.	.90 %	274.	40.90 %
9	80.0000	90.0000	4.	.60 %	278.	41.49 %
10	90.0000	100.0000	392.	58.51 %	670.	100.00 %
35-48 mesh						
CLASS	FROM	TO	ABS	REL	FREQUENCIES CUM. ABS	CUM. REL
1	0.0000	10.0000	886.	54.49 %	886.	54.49 %
2	10.0000	20.0000	40.	2.46 %	926.	56.95 %
3	20.0000	30.0000	28.	1.72 %	954.	58.67 %
4	30.0000	40.0000	24.	1.48 %	978.	60.15 %
5	40.0000	50.0000	16.	.98 %	994.	61.13 %
6	50.0000	60.0000	22.	1.35 %	1016.	62.48 %
7	60.0000	70.0000	20.	1.23 %	1036.	63.71 %
8	70.0000	80.0000	36.	2.21 %	1072.	65.93 %
9	80.0000	90.0000	10.	.62 %	1082.	66.54 %
10	90.0000	100.0000	544.	33.46 %	1626.	100.00 %
28-35 mesh						
CLASS	FROM	TO	ABS	REL	FREQUENCIES CUM. ABS	CUM. REL
1	0.0000	10.0000	208.	15.41 %	208.	15.41 %
2	10.0000	20.0000	14.	1.04 %	222.	16.44 %
3	20.0000	30.0000	12.	.89 %	234.	17.33 %
4	30.0000	40.0000	24.	1.78 %	258.	19.11 %
5	40.0000	50.0000	32.	2.37 %	290.	21.48 %
6	50.0000	60.0000	36.	2.67 %	326.	24.15 %
7	60.0000	70.0000	38.	2.81 %	364.	26.96 %
8	70.0000	80.0000	42.	3.11 %	406.	30.07 %
9	80.0000	90.0000	54.	4.00 %	460.	34.07 %
10	90.0000	100.0000	890.	65.93 %	1350.	100.00 %
20-28 mesh						
CL-35	FROM	TO	ABS	REL	FREQUENCIES CUM. ABS	CUM. REL
1	0.0000	10.0000	80.	10.53 %	80.	10.53 %
2	10.0000	20.0000	16.	2.11 %	96.	12.66 %
3	20.0000	30.0000	8.	1.06 %	104.	13.72 %
4	30.0000	40.0000	12.	1.58 %	116.	15.30 %
5	40.0000	50.0000	24.	3.17 %	140.	18.47 %
6	50.0000	60.0000	8.	1.06 %	148.	19.53 %
7	60.0000	70.0000	20.	3.69 %	176.	23.22 %

Table 4a. Classes of middling particles.

	FROM TO -200 mesh		FREQUENCIES			
	FROM	TO	ABS	REL	CUM. ABS	CUM. REL
	0.0000	10.0000	2.	.47 %	2.	.47 %
	10.0000	20.0000	3.	.70 %	5.	1.16 %
	20.0000	30.0000	0.	0.00 %	5.	1.16 %
	30.0000	40.0000	0.	0.00 %	5.	1.16 %
	40.0000	50.0000	3.	.70 %	8.	1.86 %
	50.0000	60.0000	2.	.47 %	10.	2.33 %
	60.0000	70.0000	4.	.93 %	14.	3.26 %
	70.0000	80.0000	4.	.93 %	18.	4.19 %
	80.0000	90.0000	0.	0.00 %	18.	4.19 %
	90.0000	100.0000	412.	95.81 %	430.	100.00 %

	FROM TO 150 - 200 mesh		FREQUENCIES			
	FROM	TO	ABS	REL	CUM. ABS	CUM. REL
1	0.0000	10.0000	13.	5.42 %	13.	5.42 %
2	10.0000	20.0000	2.	.83 %	15.	6.25 %
3	20.0000	30.0000	1.	.42 %	16.	6.67 %
4	30.0000	40.0000	4.	1.67 %	20.	8.33 %
5	40.0000	50.0000	3.	1.25 %	23.	9.58 %
6	50.0000	60.0000	2.	.83 %	25.	10.42 %
7	60.0000	70.0000	2.	.83 %	27.	11.25 %
8	70.0000	80.0000	1.	.42 %	28.	11.67 %
9	80.0000	90.0000	2.	.83 %	30.	12.50 %
10	90.0000	100.0000	210.	87.50 %	240.	100.00 %

CLASS	FROM TO 100 - 150 mesh		FREQUENCIES			
	FROM	TO	ABS	REL	CUM. ABS	CUM. REL
1	0.0000	10.0000	103.	26.28 %	103.	26.28 %
2	10.0000	20.0000	39.	9.35 %	142.	36.22 %
3	20.0000	30.0000	22.	5.61 %	164.	41.34 %
4	30.0000	40.0000	20.	5.10 %	184.	46.94 %
5	40.0000	50.0000	7.	1.79 %	191.	48.72 %
6	50.0000	60.0000	9.	2.30 %	200.	51.02 %
7	60.0000	70.0000	5.	1.26 %	205.	52.30 %
8	70.0000	80.0000	11.	2.81 %	216.	55.10 %
9	80.0000	90.0000	2.	.51 %	218.	55.61 %
10	90.0000	100.0000	174.	44.39 %	392.	100.00 %

SELECTED DATAGROUP

Table 5. Size distributions of middling particles.

65-100 mesh							
CLASS	FROM	TO	ABS	REL	FREQUENCIES CUM. ABS	ABS	CUM. REL
6	6.6328	9.3683	1.	.28 %	1.		.28
7	9.3683	13.232	37.	8.25 %	38.		10.53
8	13.232	18.689	80.	22.16 %	118.		22.69
9	18.689	26.397	73.	20.22 %	191.		52.91
10	26.397	37.283	46.	12.74 %	237.		65.65
11	37.283	52.660	32.	8.86 %	269.		74.52
12	52.660	74.377	14.	3.88 %	283.		78.39
13	74.377	105.05	21.	5.82 %	304.		84.21
14	105.05	148.38	27.	7.48 %	331.		91.69
15	148.38	209.57	26.	7.20 %	357.		98.89
16	209.57	296.00	4.	1.11 %	361.		100.00
48-65 mesh							
CLASS	FROM	TO	ABS	REL	FREQUENCIES CUM. ABS	ABS	CUM. REL
9	18.689	26.397	46.	12.99 %	46.		12.99
10	26.397	37.283	98.	27.68 %	144.		40.68
11	37.283	52.660	48.	13.56 %	192.		54.24
12	52.660	74.377	36.	10.17 %	228.		64.41
13	74.377	105.05	36.	10.17 %	264.		74.58
14	105.05	148.38	26.	7.34 %	290.		81.92
15	148.38	209.57	30.	8.47 %	320.		90.40
16	209.57	296.00	22.	6.21 %	342.		96.61
17	296.00	418.08	12.	3.39 %	354.		100.00
35-48 mesh							
CLASS	FROM	TO	ABS	REL	FREQUENCIES CUM. ABS	ABS	CUM. REL
9	18.689	26.397	80.	11.83 %	80.		11.83
10	26.397	37.283	124.	18.34 %	204.		30.18
11	37.283	52.660	118.	17.46 %	322.		47.63
12	52.660	74.377	70.	10.36 %	392.		57.99
13	74.377	105.05	46.	6.80 %	438.		64.79
14	105.05	148.38	58.	8.58 %	496.		73.37
15	148.38	209.57	48.	7.18 %	544.		80.47
16	209.57	296.00	64.	9.47 %	608.		89.94
17	296.00	418.08	44.	6.51 %	652.		96.45
18	418.08	590.50	22.	3.25 %	674.		99.70
19	590.50	834.03	2.	.30 %	676.		100.00
28-35 mesh							
CLASS	FROM	TO	ABS	REL	FREQUENCIES CUM. ABS	ABS	CUM. REL
9	18.689	26.397	26.	3.75 %	26.		3.75
10	26.397	37.283	50.	7.28 %	76.		10.93
11	37.283	52.660	54.	7.78 %	130.		18.73
12	52.660	74.377	56.	8.07 %	186.		26.80
13	74.377	105.05	60.	8.65 %	246.		35.45
14	105.05	148.38	44.	6.34 %	290.		41.79
15	148.38	209.57	70.	10.09 %	360.		51.87
16	209.57	296.00	90.	12.97 %	450.		64.84
17	296.00	418.08	116.	16.71 %	566.		81.56
18	418.08	590.50	86.	12.39 %	652.		93.95
19	590.50	834.03	40.	5.76 %	692.		99.71
20	834.03	1178.0	2.	.29 %	694.		100.00
20-28 mesh							
CLASS	FROM	TO	ABS	REL	FREQUENCIES CUM. ABS	ABS	CUM. REL
8	174.89	348.92	14.	2.16 %	14.		2.16
9	348.92	696.13	22.	3.40 %	36.		5.56
10	696.13	1388.8	38.	5.86 %	74.		11.42
11	1388.8	2770.9	76.	11.73 %	150.		23.15
12	2770.9	5528.2	58.	8.95 %	208.		32.10
13	5528.2	11029.	80.	12.35 %	288.		44.44
14	11029.	22044.	58.	8.95 %	346.		53.40
15	22044.	43901.	64.	9.88 %	410.		63.27
16	43901.	87586.	76.	11.73 %	486.		75.00
17	87586.	17474E+06	72.	11.11 %	558.		86.11
18	17474E+06	34863E+06	50.	7.72 %	608.		93.83
19	34863E+06	69555E+06	30.	4.63 %	638.		98.46
20	69555E+06	13877E+07	10.	1.54 %	648.		100.00

SELECTED DATAGROUP

ID.NR. TR SA EXT. 1
 1610-2 02 01 ??????
 1610-2 02 01 ??????

CHANNELGROUP 8

Table 5a. Size distributions of middling particles.

-200 mesh

CLASS	FROM	TO	ABS	FREQUENCIES		
				REL	CUM. ABS	CUM. REL
7	9.3683	13.232	4.	17.39 %	4.	17.39 %
8	13.232	18.689	1.	4.35 %	5.	21.74 %
9	18.689	26.397	2.	8.70 %	7.	30.43 %
10	26.397	37.283	3.	13.04 %	10.	43.48 %
11	37.283	52.660	3.	13.04 %	13.	56.52 %
12	52.660	74.377	9.	39.13 %	22.	95.65 %
13	74.377	105.05	1.	4.35 %	23.	100.00 %

150-200 mesh

CLASS	FROM	TO	ABS	FREQUENCIES		
				REL	CUM. ABS	CUM. REL
9	18.689	26.397	9.	25.00 %	9.	25.00 %
10	26.397	37.283	3.	8.33 %	12.	33.33 %
11	37.283	52.660	3.	8.33 %	15.	41.67 %
12	52.660	74.377	3.	8.33 %	18.	50.00 %
13	74.377	105.05	4.	11.11 %	22.	61.11 %
14	105.05	148.38	4.	11.11 %	26.	72.22 %
15	148.38	209.57	6.	16.67 %	32.	88.89 %
16	209.57	296.00	3.	8.33 %	35.	97.22 %
17	296.00	418.08	1.	2.78 %	36.	100.00 %

100-150 mesh

CLASS	FROM	TO	ABS	FREQUENCIES		
				REL	CUM. ABS	CUM. REL
9	18.689	26.397	36.	16.98 %	36.	16.98 %
10	26.397	37.283	39.	18.40 %	75.	35.38 %
11	37.283	52.660	21.	9.91 %	96.	45.28 %
12	52.660	74.377	28.	13.21 %	124.	58.49 %
13	74.377	105.05	54.	25.47 %	178.	83.96 %
14	105.05	148.38	27.	12.74 %	205.	96.70 %
15	148.38	209.57	7.	3.30 %	212.	100.00 %

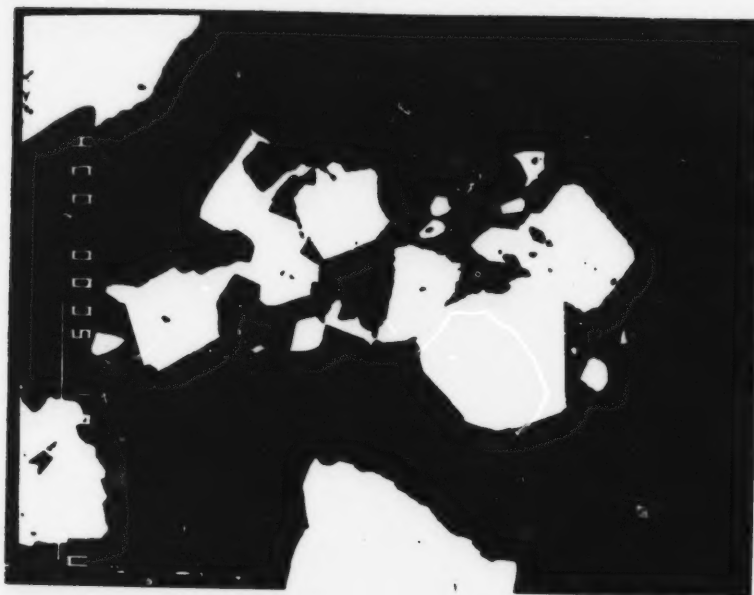


Fig. 1 - Photograph of SEM-BSE image showing unliberated hematite in Quartz, plus 1176 μm .



Fig. 2 - Goethite border (grey) on a hematite grain. SEM-BSE image, plus 1176 μm sample.

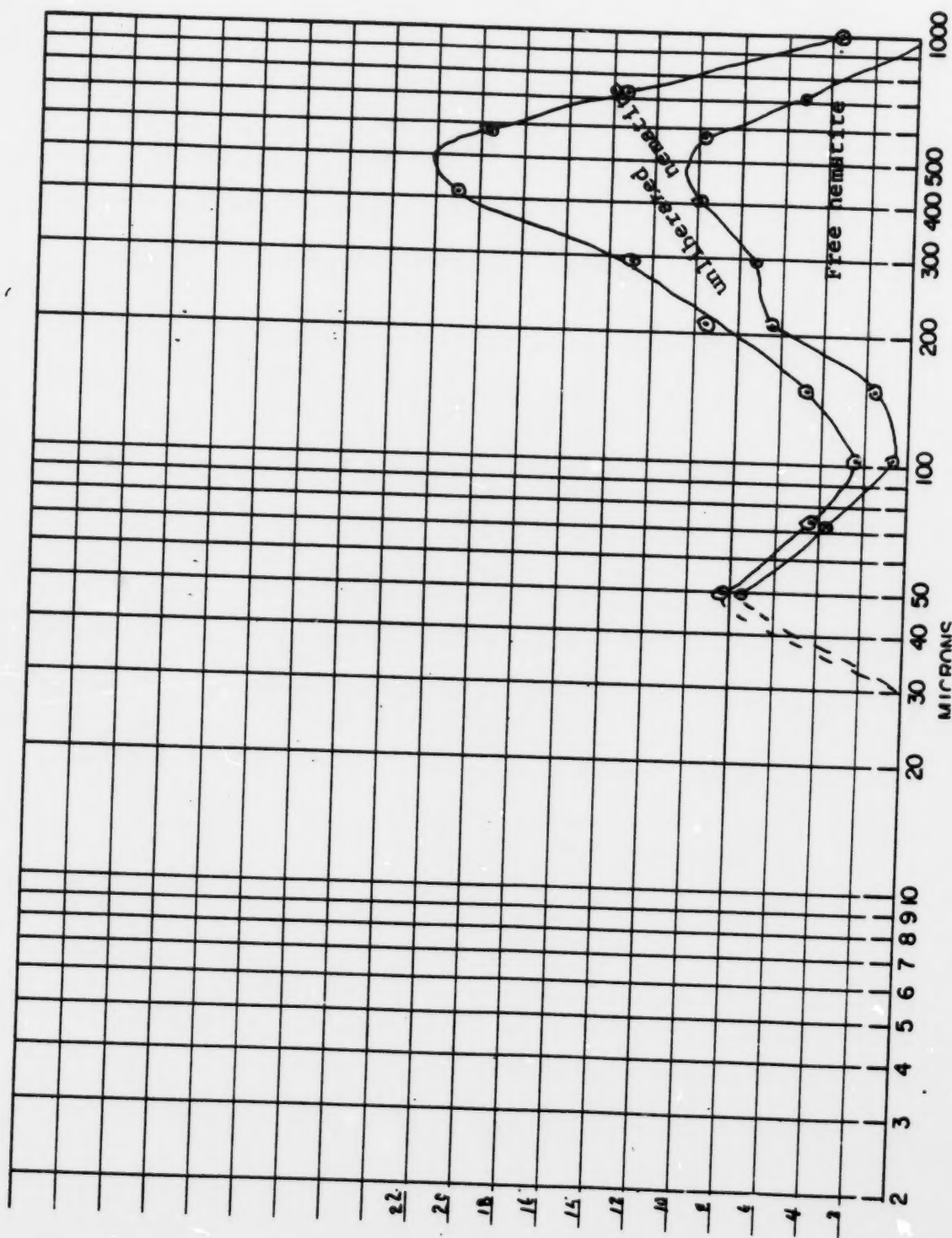


Fig. 9 - Quantities of free and unliberated hematite in cleaner tailings sample.

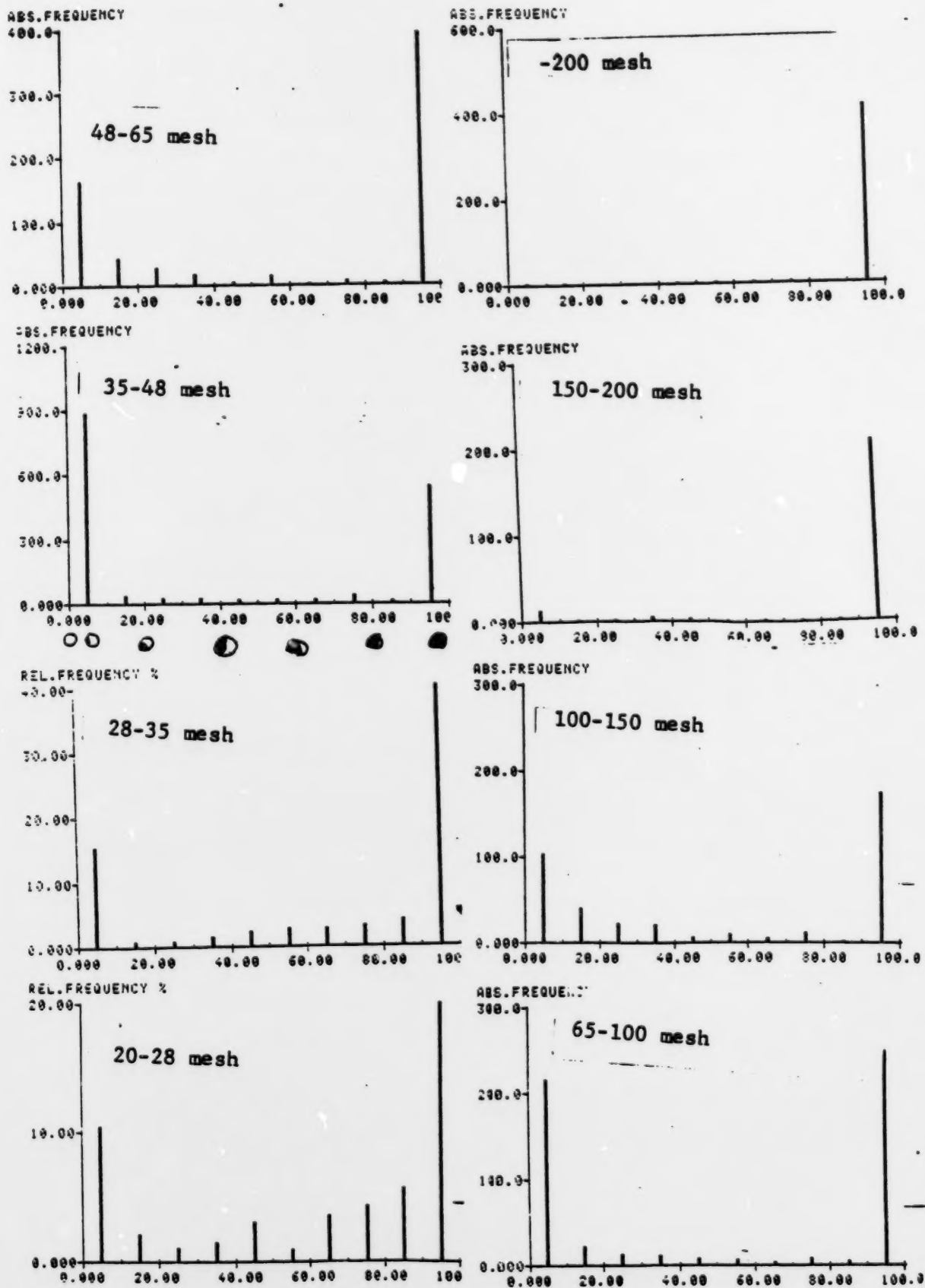
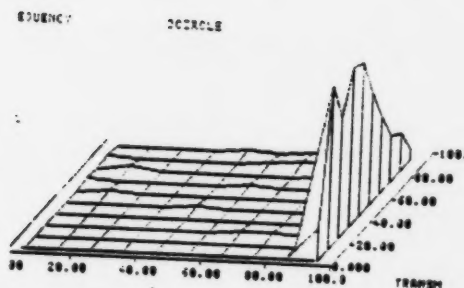
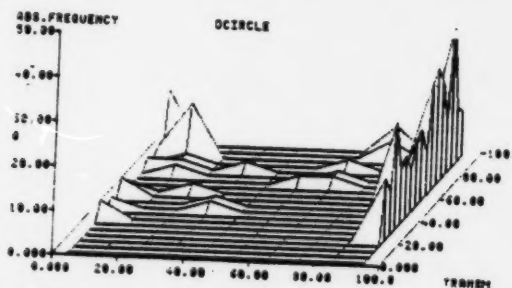


Fig. 10 - Classification of middling particles.

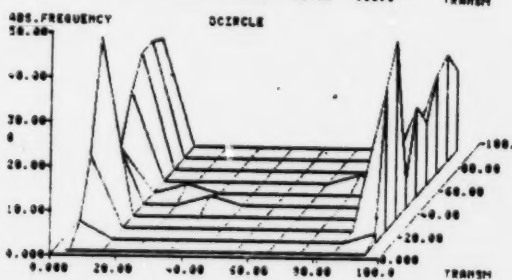
minus 200 mesh



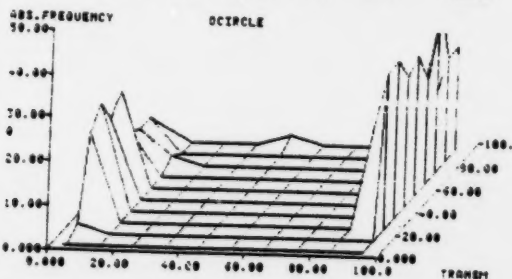
100-150 mesh



35-48 mesh



28-35 mesh



20-28 mesh

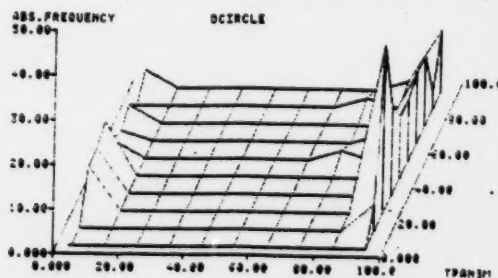


Fig. 11 - Double classification of unliberated particles. Class vs size.

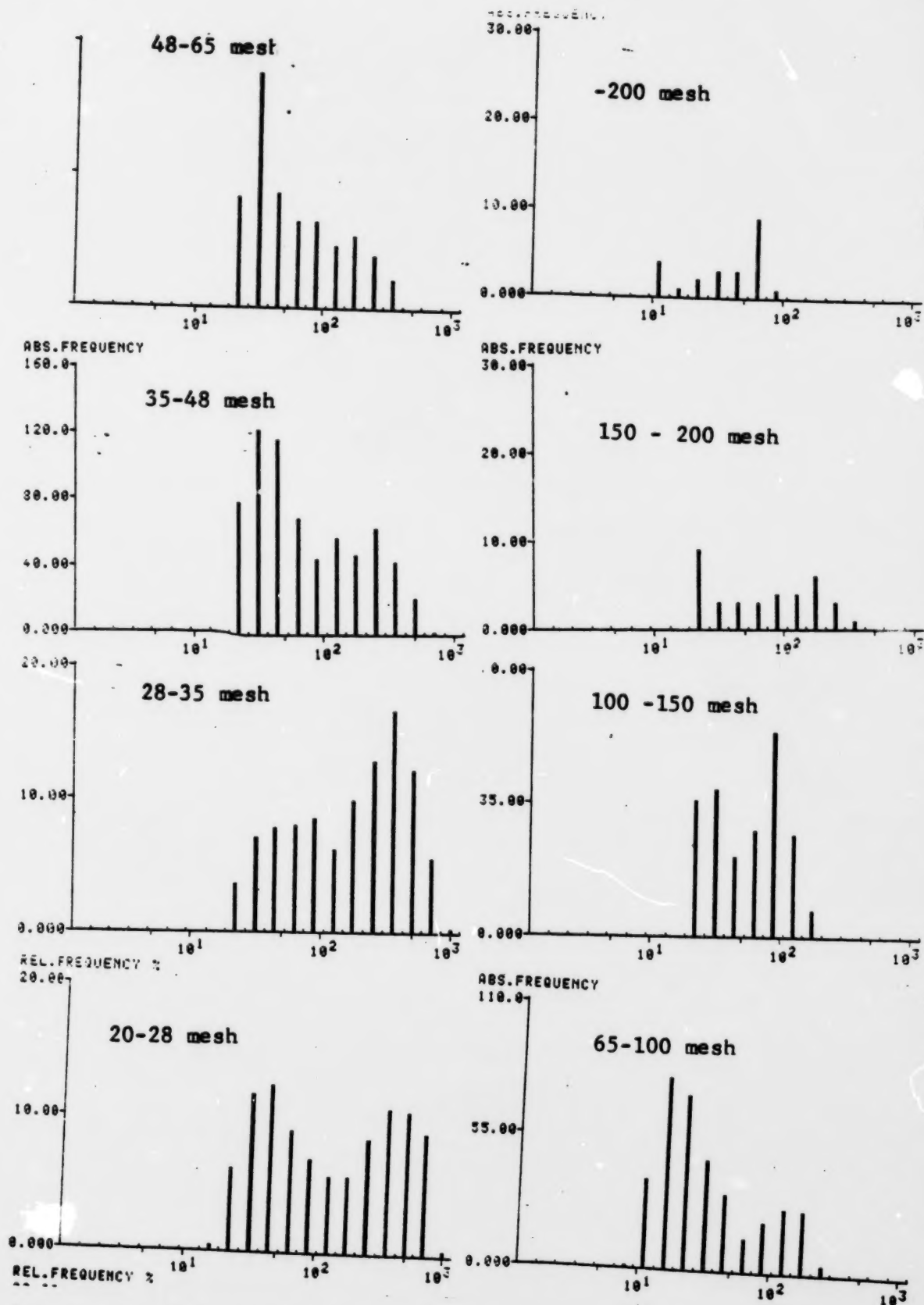


Fig. 12 - Size distributions of unliberated particles.

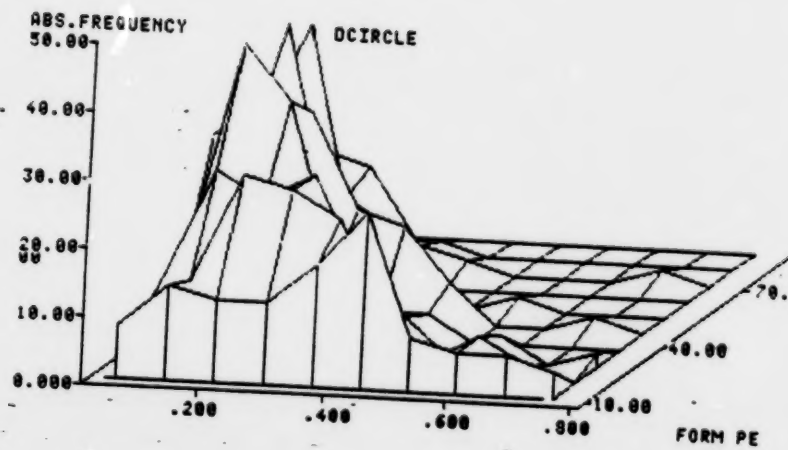


Fig. 13 - Double classification of free hematite. Shape (form PE) vs size.